Fully automated multi-criterial VMAT plan optimization for prostate cancer whole-pelvic radiotherapy

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**Objective**
Inclusion of pelvic lymph nodes in prostate radiotherapy results in large and complex target volumes with a concave shape. This study evaluates the benefit of automated VMAT optimization (VMAT$_{auto}$) compared to manual planning (VMAT$_{manual}$) for patients treated with a simultaneously integrated boost (SIB) technique.

**Materials and Methods**
Patients were treated with VMAT using a SIB plan, delivering 60 Gy and 50 Gy in 25 fractions to the prostate (PTV-P) and the pelvic lymph nodes (PTV-LN), respectively, followed by a sequential-boost plan, delivering 13 Gy in 5 fractions to the prostate (PTV-P).

All plans were optimized in the Monaco treatment planning system (Elekta AB). Fully automated planning VMAT$_{auto}$ was performed with Erasmus iCycle [1] as a preoptimizer, guided by a site-specific wishlist, containing the goal functions that are optimized in a specific order and hard constraints that must not be violated. Configuration of the autoplanning system was based on manual VMAT plans of 5 training patients.

VMAT$_{auto}$ and VMAT$_{manual}$ plans were compared for an independent set of 30 evaluation patients through dose-volume parameter analysis and blinded physician scoring.

**Results**
- All VMAT$_{auto}$ and VMAT$_{manual}$ plans were clinically acceptable.
- The radiation oncologist preferred in the blinded review the VMAT$_{auto}$ plan for 27 (90%) patients and the VMAT$_{manual}$ plan for the remaining 3 patients.
- Mean OAR doses were statistically significantly lower with VMAT$_{auto}$ for rectum, bladder and bowel (Figure 1 and Table 1).
- Plan conformity substantially improved in VMAT$_{auto}$ plans (Figure 2).
- Target volume doses were similar in both optimization approaches with slightly higher coverage V$_{95\%}$ in VMAT$_{manual}$ (Table 1).
- The number of monitor units was on average 55% and 27% higher in VMAT$_{auto}$ for the SIB-plan and the boost plan, respectively.
- Manual planning time was reduced by 76 minutes on average through VMAT$_{auto}$.

**Conclusion**
Fully automated VMAT plan optimization for whole-pelvic prostate radiotherapy with large, concave target volumes was feasible, and resulted in substantially reduced OAR doses compared to manual planning by an expert, especially for the bladder.

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**References**

**Table 1: Comparison of dosimetric parameters for the total summed treatment**

<table>
<thead>
<tr>
<th>Targets</th>
<th>VMAT$_{auto}$</th>
<th>Manual - Auto</th>
<th>p-value</th>
<th>OAR</th>
<th>VMAT$_{manual}$</th>
<th>Manual - Auto</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTV-P V$_{95%}$ (%)</td>
<td>97.8 ± 0.6</td>
<td>0.6 ± 0.8</td>
<td>&lt;0.001</td>
<td>Rectum D$_{2%}$ (Gy)</td>
<td>70.2 ± 1.6</td>
<td>1.1 ± 0.8</td>
<td>&lt;0.001</td>
</tr>
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<td>PTV-P D$_{2%}$ (Gy)</td>
<td>75.1 ± 0.1</td>
<td>-0.1 ± 0.3</td>
<td>0.020</td>
<td>Rectum D$_{95%}$ (Gy)</td>
<td>34.2 ± 4.0</td>
<td>4.5 ± 2.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>PTV-P D$_{iso}$ (Gy)</td>
<td>73.1 ± 0.1</td>
<td>-0.1 ± 0.3</td>
<td>NS</td>
<td>Bladder D$_{2%}$ (Gy)</td>
<td>66.7 ± 5.8</td>
<td>2.2 ± 2.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>PTV-LN V$_{95%}$ (%)</td>
<td>99.3 ± 0.3</td>
<td>-0.4 ± 0.6</td>
<td>0.003</td>
<td>Bladder D$_{95%}$ (Gy)</td>
<td>26.3 ± 4.2</td>
<td>10.7 ± 3.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>PTV-LN D$_{2%}$ (Gy)</td>
<td>54.4 ± 1.3</td>
<td>-0.3 ± 0.6</td>
<td>NS</td>
<td>Bowel D$_{2%}$ (Gy)</td>
<td>45.3 ± 3.3</td>
<td>0.3 ± 1.7</td>
<td>NS</td>
</tr>
<tr>
<td>PTV-LN D$_{iso}$ (Gy)</td>
<td>50.8 ± 0.2</td>
<td>-0.4 ± 0.2</td>
<td>&lt;0.001</td>
<td>Bowel D$_{95%}$ (Gy)</td>
<td>15.3 ± 3.3</td>
<td>2.1 ± 1.2</td>
<td>&lt;0.001</td>
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</tbody>
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